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Development and Use of the Documentation Design Aid

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Abstract

In aviation maintenance and inspection, work documents are critical to safety, as they act as both production control devices and job aids for mechanics and inspectors. Based on an analysis of the current state of documentation in aviation maintenance, there was a clear need to help document designers/writers utilize good human factors practice. Design guidelines were developed and tested (Patel et al, 1994) and then made accessible through a Visual Basic window, called the Documentation Design Aid or DDA, available on-screen while writing a procedure. This DDA was tested for usability by writers and for comprehension of the documents produced. A number of different evaluations showed that the DDA reduced comprehension errors significantly. The DDA is now available via a WWW site for users to download and use.

1. Documentation Needs in Aviation Maintenance

Our civil aviation system is based upon documentation. No job is complete until the paperwork is done. Civil aviation is a highly regulated and highly proceduralized industry, with these two aspects coming together in documentation. Regulators, airlines and manufacturers try to commit their knowledge and experience to documented procedures that, if followed, should ensure safety. While the human factors community may see such a rule-based world as brittle and rather shortsighted (e.g. Rasmussen, 1983) documented, standardized procedures do provide a consistent base from which to start performing tasks. They also provide a means to control workflow and to certify that work was completed. This paper is concerned with improving procedure documentation rather than arguing for or against its efficacy. If we are going to have such procedural documents for the foreseeable future, these job performance aids should at least be designed to conform to human factors good practices.

Many studies of errors in aviation maintenance cite information on documentation as a major contributing factor (e.g. Kanki and Walter, 1995). When human factors became an issue in aviation maintenance and inspection following the Aloha incident in 1988, documentation design again surfaced as a major factor. For example, Drury, Prabhu and Gramopadhye (1990) performed task analyses of many maintenance and inspection jobs to search for human/system mismatches. They found a severe mismatch between the documentation current at that time and human factors research findings in information design, e.g. Wright and Barnard (1975). Procedure documents, generally called "workcards" were in poorly-formatted text paragraphs, often in upper case letters, and poorly reproduced on dot-matrix printers. This led to an on-going research program to demonstrate that the human factors principles of good document design did apply to aviation maintenance (not easily accepted in this user community) and to devise ever-easier ways to implement good practices. Now that some success has been achieved, it is appropriate to review our work so far to see how this came about.

2. Documentation Design Issues in Aviation Maintenance

At its most basic level, document design to support tasks can be split into two issues: Product and Process. The Product is the final design of the document, and covers factor such as fidelity, usability, layout, format

and information content. Process, on the other hand, refers to the method by which the Product came into being. Was it written by engineers at a manufacturer (as many procedures begin) or was it written by regulatory technical specialists (e.g. to cover modifications required by law) or was it designed with user input (c.f. participatory design, Wilson, 1995)? Both Product and Process issues are important to developing and implementing good documentation. In this paper we will concentrate on Product, as our process always involved user input from a partner airline. Drury, Wenner and Kritkausky (1999) gives more details on the participation design process leading to our Documentation Design Aid (DDA).

Within product design we must consider that there are really two complementary factors which together define the design: content and format. Of these, content is the major design variable but has received less study in the human factors literature. Clearly, if the content is incorrect or inappropriate, then even perfect formatting cannot produce a usable product. Interestingly, in our documentation design process with airlines, content issues predominate. For example, documents do not always get revised in a timely manner to reflect aircraft configuration changes, reducing any faith the user had in the document initially. If the user finds a step which is blatantly wrong, can the user trust the remaining steps? Only recently (Wenner, Wenner, Drury and Spencer, 1997; Wenner, 2000) are we beginning to address what material should be in a workcard.

Given that content is difficult to address, does format make any difference? An example of a poorly-designed aircraft workcard was given by Drury (1998). The document had produced an unacceptable number of errors in use, and so was analyzed against the good design guidelines produced by Patel, Drury and Lofgren (1994). Of the nine responses required by the workcard, the error rate was 2.3% on those responses which did not meet the Patel et al guidelines, and 0.0% (no errors at all) on those responses which did. While 2.8% errors may sound reasonable, this gave 20.8% of workcards at least one error, obviously an unacceptable error rate. Formatting of documents can indeed have a major effort on errors.

3. Document Formatting

In this short review it is not possible to present detailed guidelines, so that the evaluation and testing of guidelines will be presented to show a logical development. The actual guidelines are available at the internet address given in Section 5.

There are formatting guidelines for aviation maintenance workcards (ATA100), published by the industry group, the Air Transport Association but these are often in conflict with human factors research findings, and are at times not followed by overworked technical writers. A short set of format guidelines was developed by Patel et al (1994) from published sources in the human factors literature. Patel et al evaluated these by comparing old and new versions of a workcard at an airline using rating scales. The new documents were significantly and overwhelmingly performed by users. This study also showed that the ordering of steps in a complex task could be improved using standard industrial engineering techniques. A study of lengthy documents used for overnight checks continued this work. Patel, Pearl, Koli, Drury, Cuneo and Lofgren (1994) developed a better format for such long documents used repeatedly, and again used rating scales to evaluate its superiority.

However, ratings and preferences may not predict user errors, so a series of studies was performed using comprehension tests of different workcard formats. These measured comprehension errors, which must at least result in an inefficiency if the error is discovered and corrected, or a more critical maintenance error if undetected. Our first study evaluated the use of a specially-written limited vocabulary maintenance language called Simplified English (SE). This had been developed by airliner manufacturers and was in wide use before any evaluation was undertaken. Chervak, Drury and Ouellette (1996) used a comprehension test of workcards with and without SE, with 175 aircraft maintenance technicians (AMTs) as subjects. They found large and significant reduction in comprehension error rates under the most difficult conditions: complex workcards and non-active English speaking AMTs. Simplified English eliminated the adverse effects of both of these variables. A subsequent test of ES on two tasks involving disassembly of small gasoline engines (Chervak, 1996) showed that there was a small but

significant performance improvement using SE. This extended the validation of SE from comprehension errors to performance errors.

At this point there was good evidence that the various elements of formatting according to good human factors practices would be effective. But the Patel et al guidelines ran to two pages of text and were not readily accepted by the writers who produced workcards. Discussions with document writers at our airline partner's and a formal design process of working in groups with writers, managers and AMTs, showed that a computer based utility would be more acceptable (Drury and Sarac, 1997)

4. The Documentation Design Aid (DDA)

Our design process produced a window-based program which could be called up from within the technical writer's computer environment. This Documentation Design Aid (DDA) incorporated all of our guidelines, and a Simplified English spell checker. In use (Drury and Sarac, 1997) the writer calls up the DDA to check a writing problem in real time. Users can enter through a menu structure or an index, when they find the information they need, they can click on an example to demonstrate its use. They can also find an explanation of *why* this guideline is needed, usually quoting a performance improvement from the research literature.

Two evaluations of the DDA were performed to demonstrate that it met its objectives. First, a small usability test measured the performance of six technical writers using both computer and paper versions of the DDA. Users took less than one hour to learn to use the job aid. At this point, they were able to find and correct almost 40% of the formatting problems in their first use of the DDA to re-write an existing workcard. All rated the DDA easy to use.

The second evaluation compared comprehension of documents produced with and without the DDA using 101 AMTs. The DDA version reduced errors by 40% and important content errors by 70%, with an increase in time to read the workcard from 9 to 11 minutes.

As a final evaluation, a recent study of 54 AMTs (Drury, Wenner and Kritkausky, 1999) compared two existing airline workcards with a DDA version of each, again using comprehension tests. Both a complex and a simple workcard showed significant performance improvements for the DDA version, with the results of the larger improvement shown in Figure 1. Errors were halved when using the DDA version.

5. DDA Conclusions

Over the past decade, human factors in documentation design has progressed from being an unrecognized need to having a proven solution. The DDA is now available for free use on the Internet (www.hfskyway.com). More importantly, we have shown that a program of repeated cycles of design and evaluation can ensure that the benefits are not illusory. Currently, a number of airlines are re-formatting workcards based on DDA criteria, and NASA is testing it for space shuttle maintenance activities.

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Figure 1: Performance of aviation maintenance technicians on three versions of a single workcard